OIPE JC109
APR 2 3 2004
PATENT & TRADEMARK OFFICE

IFW
AF / 1700

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant	:	John E. Bjorkholm et al.	Attorney Docket	:	CIL-10660
Serial No.	:	09/669,958	Art Unit	:	1756
Filed	:	September 26, 2000	Examiner	:	C. Young
For	:	Compensation Of Flare-Induced CD Changes In EUVL			

BRIEF ON APPEAL

This is an appeal to the Board of Patent Appeals and Interferences from the final rejection of Claims 1-32 mailed May 16, 2003. On November 17, 2003, a timely Notice of Appeal was filed.

I. REAL PARTIES IN INTEREST

The real parties in interest are the Regents of the University of California and the United States of America as represented by the United States Department of Energy.

II. RELATED APPEALS AND INTERFERENCES

Appellant knows of no other appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-32 are pending on appeal and stand rejected. A copy of the claims on appeal are set forth in Appendix I.

IV. STATUS OF AMENDMENTS

The applicants filed a response to the non-final office action mailed January 9, 2003, which response was entered. No other responses or amendments have been filed.

V. SUMMARY OF INVENTION

The invention is directed to compensation of flare-induced CD changes in photolithography, particularly EUV lithography. Unlike optical lithography and DUV lithography, wherein the intrinsic flare varies over the image field, the intrinsic level of flare for an extreme ultraviolet (EUV) camera (the flare level for sub resolution opaque dot in a bright field mask) is essentially constant over the image field, (changing only very near the edges of the field). Based on this recognition, compensation of flare-induced CD changes in EUV cameras can be made in accordance with the method of the present invention, which basically involves calculating the flare and its variation over the area of a patterned mask that will be imaged and then using mask biasing to largely eliminate the CD variations that the flare and its variations would otherwise cause. The general method of this invention is, in principle, applicable to optical or DUV lithography but it is impractical to implement since the intrinsic flare for those lithographies is not constant over the image field.

VI. ISSUES

Whether claims 1-32 are anticipated by Garza et al.

VII. GROUPING OF CLAIMS

Claims 1, 2, 4-23 and 25-32 are separately patentable from each other. Claim 3 stands or falls with claim 1. Claim 24 stands or falls with claim 5.

VIII. ARGUMENT

Are claims 1-32 anticipated by Garza et al.?

The applicants' claim 1 recites a method for compensating for flare-induced critical dimension changes in photolithography, comprising: calculating the flare variation over the area of a patterned mask that will be imaged, and using mask biasing to largely eliminate the critical dimension changes caused by flare and its variations. The applicants' claim 14 recites a method for eliminating unwanted critical dimension changes in extreme ultraviolet lithography, which includes: calculating the flare variation over an area of a patterned mask, and mask biasing to eliminate the critical dimension changes. The applicants' claim 15 recites, in an extreme ultraviolet camera, the improvement comprising: compensating for flare-induced critical dimension changes.

As discussed in the Background of the Invention of the subject application, the scattering of light by the components of lithographic cameras is a problem of ever-increasing importance for the semiconductor industry. Scattering causes the redirection of light from an area of an image intended to be bright into all areas of the image, including those regions intended to be dark. The resulting background illumination is called "flare," which reduces image contrast and the process window for printing. More importantly, flare also has a detrimental effect on the dimensions of critical features, referred to as critical dimensions (CD), and thus has a detrimental effect on CD control; localized flare variations (which are inevitable), lead to localized CD variations. In the manufacture of semiconductor

devices, such as microprocessors, it is extremely important that the CD's are very accurately controlled.

The compensation provided by the present invention is accomplished by biasing the photomask, which means changing the dimensions of features on the photomask so that all features on the mask print within the desired CD range. ***Mask biasing is used today to compensate for CD variations caused by optical proximity effects, but has not been previously used to also correct for flare-induced CD variations.*** This is primarily due to two reasons:

1) Flare in optical lithography using transmission optics has been limited to levels of a few percent, which is not so problematic to justify the added complexity and expense of the compensation method. This situation changes at shorter wavelengths, and for reflective optics, where the flare becomes tens of percent, which significantly degrades the performance of the camera, and must be corrected.
2) The flare in optical lithography produces a strongly non-uniform spatial distribution. This makes the determination of the compensation correction of the mask features difficult, and in particular, very computationally expensive. However for EUV lithography the spatial distribution of the flare is essentially constant, which greatly simplifies the calculation of the compensation correction.

It is the recognition that the intrinsic flare of EUVL cameras is essentially constant over the image field that makes the use of the compensation techniques of the

present invention practical. Basically the method of the invention involves calculating the flare and its variation over the area of a patterned mask that will be imaged and then using mask biasing to largely eliminate the CD variations that the flare and its variations would otherwise cause.

The reference provides a method for correcting for reflective notching. Reflective notching is an effect caused by projection of a reticle image onto topographical variations of a wafer surface. See column 3, lines 24-34 and column 12, lines 6-19. The method of the reference first identifies positions where feature edges on a reticle pattern intersect topographical variations on a wafer surface and then modifies the reticle design at such positions to mitigate the effect of reflective notching. <u>Thus, the reference uses mask biasing to compensate for CD variations caused by optical proximity effects, but does not use mask biasing to correct for flare-induced CD variations.</u> <u>There is no discussion of flare correction in the reference.</u> In the Final Office action, the Examiner admits that there is no discussion of flare correction in the reference, but argues that flare induced changes are also referred to as "back scattering of light changes." The Examiner has not pointed out exactly where such reference is found, and the applicants' find no such teaching within Garza et al.

Further, the reference does not calculate the flare variations over the area of a patterned mask that will be imaged. A further differentiation of the reference from the present application is the nature of the information that is required to perform the compensation. In the case of the present invention, the system flare must be determined either by measurement or calculation of the point spread function, and this is a property

of the optical system arising primarily from the roughness of the mirror surfaces, which can vary from system to system. In the case of the reference, the optical proximity correction only requires knowledge of the mask pattern and is the same for all optical systems having the same optical design. Therefore the rejections of claims 1, 14 and 15 should be withdrawn. Claims 2-13 and 17-20 depend from claim 1. Claims 21-32 depend from claim 14. Claim 16 depends from claim 15.

Therefore the rejection should be withdrawn.

<u>Why the appellant Believes Claims 1, 2, 4-23 and 25-32 Are Separately Patentable.</u>

The arguments for patentability of claim 1 over the reference are given above. Claim 1 is separately patentable from all other claims at least because it recites a method for use in photolithography.

With respect to claim 2, the reference at least fails to teach the step of determining the contribution that scattering makes to the point spread function of the camera.

With respect to claim 4, the reference at least fails to teach that determining the contribution that scattering makes to the point spread function of the camera is carried out by measuring the power spectral densities of the roughness of the mirrors that comprise the camera.

With respect to claim 5, the reference at least fails to teach that determining the contribution that scattering makes to the point spread function of the camera is carried out by using extreme ultraviolet interferometry.

With respect to claim 6, the reference at least fails to teach the step of checking the intrinsic flare level experimentally including measuring the flare level at many points within the exposure field, comparing the measurements with the calculations.

With respect to claim 7, the reference at least fails to teach the step of convolving the point spread function due to scattering with the aerial image produced by the camera in the absence of scattering.

With respect to claim 8, the reference at least fails to teach that the method is carried out using a bright field mask or a dark field mask.

With respect to claim 9, the reference at least fails to teach the step of obtaining an approximation to the aerial image by convolving the point spread function of the camera due to scattering with the ideal aerial image of the mask, which neglects the effects of aberrations and diffraction.

With respect to claim 10, the reference at least fails to teach the step of convolving the point spread function of the camera due to scatter with the ideal aerial image of the mask.

With respect to claim 11, the reference at least fails to teach the step of determining the printed critical dimensions of all the critical features of the mask by using a simple resist threshold model or by using a detailed resist model that

incorporates various processing steps including post-exposure bakes and development.

With respect to claim 12, the reference at least fails to teach the step calculating the flare variation over the projected mask pattern using tables constructed from experimentally measured critical dimensions for a print of an unbiased mask.

With respect to claim 13, the reference at least fails to teach the use of an extreme ultraviolet camera.

With respect to claim 14, there is no recitation in any other claims of the present application, nor does the reference teach a method for compensating for flare-induced critical dimension changes <u>extreme ultraviolet lithography</u>.

With respect to claim 15, there is no recitation in any other claims of the present application, nor does the reference teach an apparatus for compensating for flare-induced critical dimension changes <u>in an extreme ultraviolet camera</u>.

With respect to claim 16, there is no recitation in any other claims of the present application, nor does the reference teach an apparatus for calculating the flare variation over an area of a patterned mask to be imaged by the camera, and using mask biasing to eliminate critical dimension variations caused by flare variations.

With respect to claim 17, there is no recitation in any other claims of the present application, nor does the reference teach minimizing the flare in the aerial

image before calculating the flare variation by utilizing either a bright field mask or a dark field mask.

With respect to claim 18, there is no recitation in any other claims of the present application, nor does the reference teach a method using a bright field mask with a positive photoresist.

With respect to claim 19, there is no recitation in any other claims of the present application, nor does the reference teach the use of a dark field mask with a negative photoresist.

With respect to claim 20, there is no recitation in any other claims of the present application, nor does the reference teach calculating the flare variations using a phase-shift mask.

With respect to claim 21, there is no recitation in any other claims of the present application, nor does the reference teach, in an <u>extreme ultraviolet lithography</u> system, the steps wherein calculating the flare variation is carried out by determining the contribution that scattering makes to the point spread function of the camera; calculating the aerial image of the mask pattern that is to be imaged which yields the variation of the flare over the projected aerial image; and based on the aerial image calculated, determining the printed critical dimensions of all the critical features of the mask; then biasing the mask so that the desired critical dimensions are printed.

With respect to claim 22, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, that the mask biasing is carried out in a mask fabrication process.

With respect to claim 23, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, that the step of determining the contribution that scattering makes to the point spread function of the camera is carried out by measuring the power spectral densities of the roughness of the mirrors that comprise the camera.

With respect to claim 25, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, checking the intrinsic flare level experimentally including measuring the flare level at many points within the exposure field, comparing the measurements with the calculations.

With respect to claim 26, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, convolving the point spread function due to scattering with the aerial image produced by the camera in the absence of scattering.

With respect to claim 27, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, using a bright field mask or a dark field mask.

With respect to claim 28, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet

lithography system, convolving the point spread function of the camera due to scattering with the ideal aerial image of the mask, which neglects the effects of aberrations and diffraction.

With respect to claim 29, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, convolving the point spread function of the camera due to scatter with the ideal aerial image of the mask.

With respect to claim 30, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, that determining the printed critical dimensions of all the critical features of the mask is carried out using a simple resist threshold model or by using a detailed resist model that incorporates various processing steps including post-exposure bakes and development.

With respect to claim 31, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, that calculating the flare variation over the projected mask pattern is carried out using tables constructed from experimentally measured critical dimensions for a print of an unbiased mask.

With respect to claim 32, there is no recitation in any other claims of the present application, nor does the reference teach, in an extreme ultraviolet lithography system, a method using an extreme ultraviolet camera.

Accordingly it is submitted that the rejections of claims 1-32 as being anticipated by Garza et al. under 35 U.S.C. § 102(b) is improper and should be reversed.

Respectfully submitted,

John P. Wooldridge

John P. Wooldridge
Attorney for Appellants
Registration No. 38,725
Tel. No. (808) 270-1011

Dated: April 19, 2004

IX APPENDIX I

1. A method for compensating for flare-induced critical dimension changes in photolithography, comprising:

calculating the flare variation over the area of a patterned mask that will be imaged, and

using mask biasing to largely eliminate the critical dimension changes caused by flare and its variations.

2. The method of Claim 1, wherein calculating the flare variation is carried out by determining the contribution that scattering makes to the point spread function of the camera; calculating the aerial image of the mask pattern that is to be imaged which yields the variation of the flare over the projected aerial image; and based on the aerial image calculated, determining the printed critical dimensions of all the critical features of the mask; then biasing the mask so that the desired critical dimensions are printed.

3. The method of Claim 1, wherein mask biasing is carried out in a mask fabrication process.

4. The method of Claim 2, wherein determining the contribution that scattering makes to the point spread function of the camera is carried out by

measuring the power spectral densities of the roughness of the mirrors that comprise the camera.

5. The method of Claim 2, wherein determining the contribution that scattering makes to the point spread function of the camera, including the effects of diffraction and scattering, is carried out by using extreme ultraviolet interferometry.

6. The method of Claim 2, wherein determining the contribution that scattering makes to the point spread function of the camera, additionally includes checking the intrinsic flare level experimentally including measuring the flare level at many points within the exposure field, comparing the measurements with the calculations.

7. The method of Claim 2, wherein calculating the aerial image of the mask pattern that is to be imaged is carried out by convolving the point spread function due to scattering with the aerial image produced by the camera in the absence of scattering.

8. The method of Claim 2, wherein the method is carried out using a bright field mask or a dark field mask.

9. The method of Claim 2, wherein calculating the aerial image of the mask pattern that is to be imaged is carried out by obtaining an approximation to the aerial image by convolving the point spread function of the camera due to scattering with the ideal aerial image of the mask, which neglects the effects of aberrations and diffraction.

10. The method of Claim 1, wherein calculating the flare variation is carried out by convolving the point spread function of the camera due to scatter with the ideal aerial image of the mask.

11. The method of Claim 2, wherein determining the printed critical dimensions of all the critical features of the mask is carried out using a simple resist threshold model or by using a detailed resist model that incorporates various processing steps including post-exposure bakes and development.

12. The method of Claim 1, wherein calculating the flare variation over the projected mask pattern is carried out using tables constructed from experimentally measured critical dimensions for a print of an unbiased mask.

13. The method of Claim 1, additionally including using an extreme ultraviolet camera.

14. A method for eliminating unwanted critical dimension changes in extreme ultraviolet lithography, which includes:

calculating the flare variation over an area of a patterned mask, and mask biasing to eliminate the critical dimension changes.

15. In an extreme ultraviolet camera, the improvement comprising: compensating for flare-induced critical dimension changes.

16. The improvement of Claim 15, which is carried out by calculating the flare variation over an area of a patterned mask to be imaged by the camera, and using mask biasing to eliminate critical dimension variations caused by flare variations.

17. The method of Claim 1, additionally including minimizing the flare in the aerial image before calculating the flare variation by utilizing either a bright field mask or a dark field mask.

18. The method of Claim 17, wherein a bright field mask is used with a positive photoresist.

19. The method of Claim 17, wherein a dark field mask is used with a negative photoresist.

20. The method of Claim 1, wherein calculating the flare variations is carried out using a phase-shift mask.

21. The method of Claim 14, wherein calculating the flare variation is carried out by determining the contribution that scattering makes to the point spread function of the camera; calculating the aerial image of the mask pattern that is to be imaged which yields the variation of the flare over the projected aerial image; and based on the aerial image calculated, determining the printed critical dimensions of all the critical features of the mask; then biasing the mask so that the desired critical dimensions are printed.

22. The method of Claim 14, wherein mask biasing is carried out in a mask fabrication process.

23. The method of Claim 21, wherein determining the contribution that scattering makes to the point spread function of the camera is carried out by measuring the power spectral densities of the roughness of the mirrors that comprise the camera.

24. The method of Claim 21, wherein determining the contribution that scattering makes to the point spread function of the camera, including the effects of diffraction and scattering, is carried out by using extreme ultraviolet interferometry.

25. The method of Claim 21, wherein determining the contribution that scattering makes to the point spread function of the camera, additionally includes checking the intrinsic flare level experimentally including measuring the flare level at many points within the exposure field, comparing the measurements with the calculations.

26. The method of Claim 21, wherein calculating the aerial image of the mask pattern that is to be imaged is carried out by convolving the point spread function due to scattering with the aerial image produced by the camera in the absence of scattering.

27. The method of Claim 21, wherein the method is carried out using a bright field mask or a dark field mask.

28. The method of Claim 21, wherein calculating the aerial image of the mask pattern that is to be imaged is carried out by obtaining an approximation to the aerial image by convolving the point spread function of the camera due to

scattering with the ideal aerial image of the mask, which neglects the effects of aberrations and diffraction.

29. The method of Claim 14, wherein calculating the flare variation is carried out by convolving the point spread function of the camera due to scatter with the ideal aerial image of the mask.

30. The method of Claim 21, wherein determining the printed critical dimensions of all the critical features of the mask is carried out using a simple resist threshold model or by using a detailed resist model that incorporates various processing steps including post-exposure bakes and development.

31. The method of Claim 14, wherein calculating the flare variation over the projected mask pattern is carried out using tables constructed from experimentally measured critical dimensions for a print of an unbiased mask.

32. The method of Claim 14, additionally including using an extreme ultraviolet camera.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant	:	John E. Bjorkholm et al.	Attorney Docket	:	CIL-10660
Serial No.	:	09/669,958	Art Unit	:	1756
Filed	:	September 26, 2000	Examiner	:	C. Young
For	:	Compensation Of Flare-Induced CD Changes In EUVL			

FEE AUTHORIZATION FOR FILING A BRIEF IN SUPPORT OF APPEAL UNDER 37 CFR 1.17(c)

The fee required for filing a Brief in support of an appeal is **$330.**

The Commissioner is hereby authorized to deduct the required fee (**$330.**) from Deposit Account 501913.

Respectfully submitted,

John P. Wooldridge

John P. Wooldridge
Attorney for Appellants
Registration No. 38,725
Tel. No. (808) 270-1011

Dated: April 19, 2004